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O. Ringdal, and K. Julshamn

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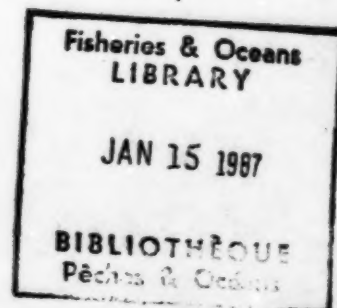
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Ole Ringdal and Kaare Julshamm,  
Nutritional Institute of the Fisheries Directorate

## SELENIUM — AN IMPORTANT NUTRIENT FOR SALMONIDS

Need for minerals and trace elements among salmonid fishes has been recently presented as a factor possibly connected with the Hitra disease. It is obvious that the need of fish for these nutrients is different from that of terrestrial animals, and therefore experiences gained with domestic animals can not be transferred directly to concern fish. Thus, need and tolerance of micronutrients must be assessed by independent fish studies. This article summarizes today's knowledge about selenium as a necessary trace element in the diet of fish, in view of what is generally known about selenium metabolism in mammals.

Selenium is an element with chemical properties closely related to those of sulphur. Therefore, it can be replaced with sulphur in several biologically active compounds. Methionine and cysteine (protein constituents), which are important sulphurous amino acids, may, for example, form new selenium variants such as selenomethionine and selenocysteine. The occurrence of selenium in nature is closely related to that of sulphur, even though sulphur is found in quantities 6 000 times bigger than selenium. Therefore, selenium is considered a trace element in both inorganic and biological systems.

Selenium was acknowledged, as late as 1957, to be an essential trace element for mammals, and in the beginning of the 1970's it was identified as a necessary component of the enzyme glutathion peroxidase. It was shown

that selenium deficiency causes serious diseases in several domestic animal species. Deficiency diseases of domestic animals such as pigs, sheep, horses, and chickens have been known long, and it has been verified that supplementary selenium cures diseases attributable to low selenium intake in man as well.

Selenium is found in biological tissues in very small quantities. Concentrations exceeding 1 mg/kg (1/1 000 000) are seldom found in animal products. In mammals and birds, the need for selenium is probably somewhat below 0.1 mg/kg in the feed and is as a rule satisfied by a normal diet. The best selenium sources are marine products, entrails, and grain grown in selenium-containing soil. On the other hand, the selenium need of fishes is not known much about, but since fish and marine organisms have a high selenium content, their need for this element may be high as well.

The greatest limitation affecting research in this area consisted for a long time of inaccurate analytical methods. However, improvement of the analytical instruments now makes it possible to carry out these difficult measurements. Reliable selenium analyses together with clinical studies of test animals have recently produced new interesting information about the deficiency, need and toxicity of selenium in several animal species.

#### Function

As mentioned, selenium is contained by the combination glutathione peroxidase. This enzyme plays a role in the decomposition of toxic peroxides formed by oxidation of fat in cell membranes. Thus, selenium acts, together with vitamin E, as a protection against oxidative "stress". Glutathione peroxidase is active in all cells but plays a particularly important role in the red blood corpuscles transporting oxygen to the tissues. Selenium has several less known functions in the organism as well, for example in connection with the detoxification of heavy metals.

Both selenium-mercury and selenium-cadmium have been identified, and the liver is probably the most essential organ to form these. The liver also detoxifies selenium<sup>in case</sup> of overdose, and the separation takes place by means of the kidneys or the lungs (in mammals) by acute poisonings. Also in fish, selenium has been identified as a component of the enzyme glutathione peroxidase. A selenium-mercury interaction (detoxification ?) has been verified i.a. in cod (research by the Nutritional Inst. , Ringdal and Julshamm). Therefore, there is much to indicate that selenium functions in the same manner in fish and terrestrial animals.

### Deficiency

Selenium deficiency is known from many domestic animal species. The symptoms include often destruction of muscular tissue. Heart muscles may be damaged as well. Reduced administration of selenium results in a fall in the enzymatic action of glutathione peroxidase, and little selenium will be found in the tissues. A simultaneous deficiency of vitamin E increases the selenium deficiency and may lead to serious diseases.

In salmon, the deficiency symptoms include i.a. yellow liver and diverticula, which probably are connected with fat peroxidation. Other selenium and E vitamin deficiency symptoms in salmon fry include extreme anaemia, pale gills, increased plasma protein, enlarged gall bladder, and muscular degeneration. Also, tests performed with salmon fry indicated a decreased glutathione peroxidase activity, while the fish showed poor appetite and disturbed swim movements.

Selenium and vitamin E deficiency was verified in an experiment with rainbow trout as well. The measurements indicated reduced glutathione peroxidase activity and reduced selenium levels in the liver and blood plasma. The trout showed poor growth, but no major pathological changes in the muscle tissue were registered. Table 1 shows selenium concentrations in feed, that have resulted in a deficiency.

### Toxicity

Selenium is not only an essential nutrient but also a potential toxin in excessive doses. The distance between deficiency and toxicity is not great, and cases of poisoning among domestic animals are known from areas with a high selenium content in the soil.

The symptoms of selenium poisoning in rainbow trout are unspecific, with an obvious disturbance in swimming movements. However, it may have a dramatic effect on growth, feed consumption, and mortality. Secretion of superfluous selenium takes place in fish probably by means of the gall bladder and the gills and kidneys. Differences have been shown to exist between the metabolism of selenium deriving from feed and that deriving from water, but in both cases the liver is the central organ for the storage, metabolism, and detoxification of the element. When poisoning takes place, selenium metabolism in the liver is probably the factor limiting detoxification, and an accumulation of the element occurs in this organ. It seems that excessive carbohydrate in feed aggravates selenium poisoning in rainbow trout. Furthermore, both mercury and copper have been found to increase in the liver by high selenium intake, which shows that the different elements interact, thus possibly affecting selenium metabolism in fish. It is difficult to set a toxicity limit for selenium, as the selenium detoxification capacity of the liver may be changed by feed components such as available carbohydrates, heavy metals, and "liver toxins". Table 1 shows selenium concentrations in feed, that have resulted in poisonings among fish.

### Requirement

Factors used for calculating the requirement are optimal growth, healing of deficiency symptoms, or maximal enzymatic activity of glutathione peroxidase. Also, an increased selenium supplement in excess of the normal requirement is used for prevention of certain diseases in mammals, but this is not recommendable in view of nutritional factors.

The selenium requirement of salmonids has been calculated to be 0.15 - 0.38 mg/kg dry feed (Table 1). On the basis of a constant ratio of

selenium in the rainbow trout liver and the kidneys, Hilton and collaborators in Canada indicated an optimal requirement of 0.35 mg/kg, in agreement with earlier results. For channel catfish, the requirement is calculated to be 0.1 - 0.5 mg/kg. All these assumed requirements are lower than the concentrations today found in commercial fish feeds (Table 2), and supplements are not needed on the basis of the existing scientific data. The same conclusion is reached in a recent article in Norsk Fiskeoppdrett (Norwegian Fish Breeding, No. 3-85) by Julshamn and collaborators.

### Conclusion

The most fisheries experiments are carried out with small fishes, but since selenium requirement probably decreases with increasing size of fish, it can be assumed that today's fish feed contains sufficient selenium to satisfy the normal requirements of fish (Tables 1 and 2). As mentioned, some feed and environmental factors may cause a change in the selenium requirement, which may be increased by intensive feeding, use of rancid fat, abundant polyunsaturates, low vitamin E supplement, (low vitamin C supplement ?), and several diseases. Little is known at the present time about the general effect of water temperature, high growth rate and fish density on nutrient requirements. It is obvious that more research is needed in this field. Both deficiencies and poisonings can easily become real problems, if more detailed knowledge is not gained in the field about the importance of micro nutrients in the nutrition of fish.

References used for this article are available from Ole Ringdal, Nutritional Inst. of the Fisheries Directorate.

Table 1 Deficiency, requirement, and toxicity of selenium in fish

| Species         | Size<br>(g) | Deficiency<br>(mg/kg) | Requirement<br>(mg/kg) | Intoxication<br>(mg/kg) |
|-----------------|-------------|-----------------------|------------------------|-------------------------|
| Salmon          | 0.1-4.5     | < 0.04                |                        |                         |
| "               | (fry)       | 0.08                  |                        |                         |
| Rainbow trout   | 14-41       | < 0.07                | > 0.15                 |                         |
| "               | 14-33       |                       | 0.15-0.38              | 13(3)*                  |
| "               | 10-300      | 0.06                  |                        | 10                      |
| Channel catfish | 70-850      | 0.06                  | 0.1-0.5                | 15                      |

\*) Chronic poisoning over a long time

Table 2 Selenium content in commercial fish feed for salmonids

| Feed type  | Selenium content<br>(mg/kg) |
|------------|-----------------------------|
| Dry feed   | appr. 1.25                  |
| "          | 0.84                        |
| Myk pellet | 0.6-0.7                     |
| "          | 0.7-1.5                     |